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INNOVATION AND PRODUCT QUALI
UNDER THE TOTAL PACKA
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Thomas K. Glennan

PREPARED FOR:
UNITED STATES AIR FORCE PROJECT RAND

The RAND Corporation
SANTA MONICA • CALIFORNIA

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The RAND Corporation
1700 MAIN ST • SANTA MONICA • CALIFORNIA • 90406

PREFACE

This Project RAND Memorandum looks at some of the more general issues raised by the type of contract adopted in developing and procuring the C-5A heavy logistics transport aircraft. The C-5A program has involved several new management and contractual procedures. Among the most significant innovations in this program was the so-called Total Package Procurement Concept (TPPC), under which the development and production of the system were contracted for simultaneously. Important components of this concept were the vigorous contract definition activities and the series of terms and conditions that inhibit contract changes and require the contractor to correct deficiencies in the system.

Following the award of contracts to the Lockheed Corporation and General Electric in September 1965, the Air Force undertook a review of the early experiences in the C-5A program to evaluate the usefulness of these procedures. One of the observations made in this review was that TPPC might inhibit innovation and erode quality in new systems. Robert Charles, Assistant Secretary of the Air Force (Installations and Logistics), asked RAND to consider the problem of how this might come about. This Memorandum has been prepared with the intent of presenting the issues rather than of reaching a firm conclusion that TPPC does or does not inhibit innovation.

During the preparation of this Memorandum, the author benefited from extensive conversations with aerospace industry and Air Force personnel. Within The RAND Corporation, particular thanks go to Harrison Campbell, George Hall, Robert Perry, and Giles Smith for their useful comments and criticism.

SUMMARY

The Total Package Procurement Concept (TPPC) introduced on the C-5A program is a significant innovation in procurement policy. Senior Department of Defense and defense industry spokesmen have questioned the value of the concept and the degree to which it should be applied to Department of Defense development activities. This Memorandum specifically addresses only the questions: What are the potential impacts of TPPC on innovation in new developments and the quality of the resulting systems?

Throughout this Memorandum, TPPC is treated as a combination of three components: the Contract Definition Phase (CDP), "bundle bidding," and a series of contractual terms and conditions designed to inhibit contract changes. Bundle bidding is the concept of contracting simultaneously for development and a substantial portion of the production run. The addition of bundle bidding and change-inhibiting contract clauses to CDP tend to make the results of CDP more binding on both the government and the contractor, because a firm production commitment is made and changes are more difficult to justify.

The Memorandum reaches the following tentative conclusions:

(1) The contract definition process inherent in TPPC together with the motivations of both the government and the contractor require that most significant technical advances associated with a program be made prior to the contract award. As a result, the Advanced and Exploratory Development activities of the Department of Defense and the independent research and development activities of the contractors become even more important to the technical progress of military hardware than they were in the past.

(2) The introduction of TPPC appears to shift the significant role of government personnel from the acquisition to the conceptual and definition phases by increasing the importance of government direction in the CDP and reducing the importance of its direction in the acquisition phase.

(3) Unless the contractor is given a clear indication of the value of various levels of system performance, he will very likely attempt to provide a minimum cost system consistent with the specifications. The initial specifications given in the request for proposal must therefore be of high quality as must the system specificatio associated with the work statement in the contract.

(4) The greater formalization of the definition process and the inhibition of changes may tend to make the process of development planning and management more objective. However, it may also make it more difficult to introduce judgments on more qualitative and subjective aspects of system performance. To the extent that innovation is associated with such judgments, it may tend to be inhibited. Clearly this problem is related to the quality of the organizations and personnel involved with the program.

(5) Imposition of an absolute dollar ceiling on changes could have detrimental effects. Changes should be made or rejected solely on their value relative to their cost.

(6) TPPC seems most likely to have adverse effects upon innovation and product quality in situations where the requirement is uncertain, the need is extremely urgent, the technology is unproved, or where the measures of system effectiveness are diffuse and qualitative.

CONTENTS

I. INTRODUCTION

The C-5A procurement program is a significant innovation in Air Force procurement policy. For the first time in many years, the development and a major proportion of the production of a major aircraft system were contracted for simultaneously. Moreover, the contract was awarded after a prolonged and thorough technical and price competition, the Contract Definition Phase (CDP). The contract itself was fixed price (with incentives) and contained terms and conditions designed to minimize program changes and cost escalation. The concept of simultaneously contracting for both development and production, together with contract terms and conditions designed to inhibit unnecessary changes, and the definition activities required to write such a contract has been christened the Total Package Procurement Concept (TPPC).

As is natural with any innovation in procedures, TPPC has caused many arguments concerning its worth, its costs, and its effects on the development and production process. In particular, questions have been raised concerning possible inhibitions on technological innovations or erosion of quality in the developed product. The purpose of this Memorandum is to examine these issues.

Since the bulk of this Memorandum is devoted to considering the mechanisms by which TPPC could inhibit innovation or erode quality, it is perhaps worth briefly noting the benefits that advocates of TPPC expect to follow from the use of this concept. These benefits include the following:*

(1) TPPC requires a tightening of design and configuration discipline on the part of the contractor. At the same time it forces the government to be more specific in telling the industry what is wanted.

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*Total Package Procurement Concept, Department of the Air Force, 10 May 1966, pp. 3-5.

(2) It inhibits unrealistic "salesmanship" or "buy-in" bidding and allows the Department of Defense to make a choice among competing contractors on the basis of binding commitments on the performance and price of the system.

(3) Because of production commitments, the contractor is motivated to design initially for economical production, reliability, and maintainability.

(4) The contractor is motivated to obtain supplies from the most efficient source.

(5) Because of increased competition at program initiation, there will be less need for subsequent competitive reprocurement of components.

(6) The establishment of commitments in a competitive environment forces the winning contractor to be efficient.

Against these alleged benefits of TPPC, the decisionmakers must weigh the possibility that TPPC will inhibit technological advance or lead to products of an inferior quality. It is not surprising that this concern has been raised by senior Air Force personnel and industry spokesmen. Previous development and procurement policies associated with weapons systems now in the Air Force inventory were quite different. Such policies led to the development of equipment and systems that have generally appeared to provide the United States with an overall technical superiority. It is difficult to abandon policies that have produced such a situation, particularly when senior industry and military personnel have worked with them. Yet to say we have done well is not to say we cannot do better.

A true test of the assertion that TPPC erodes quality or inhibits innovation could be made only after a series of programs have been completed using this concept, and indeed such a test would be convincing only if direct comparisons could be made with developments carried on under alternative procurement policies. It is unlikely that such comparisons will ever be completely successful; in any case, the decision to continue or discontinue the use of TPPC

must be made before such evidence will be available This Memorandum merely provides a structure for examining the question. Ultimately, the decision on whether or not to use TPPC will have to be based on judgments of the effects of TPPC on quality and innovation in weapons systems as well as on the price actually paid by the government for these systems.

Section II is a short historical discussion of weapons system procurement as a basis for indicating the motivations for introducing the TPPC and as a means of clarifying what is meant by TPPC. Section III discusses contractor motivations. Section IV examines the potential effects of TPPC on prime contractor, subcontractor, supplier, and government decisionmaking. Finally, Section V offers some alternatives to TPPC, and Section VI presents the conclusions.

II. THE ANTECEDENTS OF TPPC

The decade of the 1950s was a tumultuous one for the Air Force R&D community. The research and development budgets rose rapidly, and, more important, the R&D cost of new systems rose even more rapidly. The complexity of the projects required new management approaches and seemed constantly to defy the capabilities of development organizations. Many expensive developments were canceled as technology proved balky, costs escalated, and requirements changed. The Department of Defense reacted to these difficulties with new management systems, closer review by high-level staff, new forms of contracts, and a new structuring of the development process. Most of these changes had had little proof testing, emerging full blown on new programs. This has made their evaluation difficult, for it is hard to separate deficiencies in the new techniques themselves from just plain poor judgment in their application.

Perhaps the dominant quality of the developments in the 1950s was the escalation of costs.* The conclusion generally reached by those who tried to find the cause was that most of the escalation was due to poor initial definition of the project. This poor definition took three forms: a lack of appreciation of the true needs of the operational forces, a lack of appreciation of the true scope of the development task, and a failure to make realistic appraisals of the difficulties of solving technological problems. At the same time there was an implicit and sometimes an explicit assumption that part of the reason for the observed escalation of costs was that the contractors did not have a great deal of incentive to keep the cost from escalating. Development was largely accomplished with the use of cost-plus contracts to which additional tasks (carrying additional

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*A. W. Marshall and W. H. Meckling, "Predictability of Costs, Time, and Success of Development," The Rate and Direction of Inventive Activity: Economic and Social Factors, R. Nelson (ed.), New York, National Bureau of Economic Research, 1962; M. J. Peck and F. M. Schere The Weapons Acquisition Process: An Economic Analysis, Boston, Graduat School of Business Administration, Harvard University, 1962, pp. 21-23.

fee) were easily added. Little direct evidence can be found that costs were indeed higher than they needed to be in development. However, dramatic savings when component equipment was reprocured on a competitive basis contributed to a general suspicion that costs were sometimes too high.

In general, the Air Force attempted to meet these problems by improving the planning of development programs (for example, through the introduction of the weapons system management doctrine) and by strengthening the administrative apparatus for monitoring and directing contractor activities. The new administration in 1961 directed increased use of incentive contracts for the procurement of operational system development, and the project (now contract) definition phase was instituted. Incentive contracts and the Contract Definition Phase (CDP) complemented each other in an important fashion. For a contractor to be willing to take a contract that ties his profit to his performance, the task must be carefully defined. However, it was recognized from the beginning that an incentive contract will provide a contractor not only with a motivation to reduce his costs relative to the target cost, but also with an incentive to try to obtain the highest possible target cost. The net effect of these two motivations need not lead to the lowest possible cost to the government. As a result, the CDP was generally to be performed with two or more contractors in competition with one another. The competition was intended to insure that the final price of the system development would be as low as possible.

Contract definition represented a profound change in military development practices. Prior to its introduction, there was a tendency to choose a contractor on the basis of relatively scanty data and experimentation. The configuration was then defined more thoroughly in the early phases of the development activity through a partnership between the government and a single individual source. The introduction of the definition phase was not so much the introduction of a new activity as it was the shifting of an old one from a sole source environment to a competitive environment. This is true

not only with respect to the definition phase itself but with respect to some part of the conceptual phase also.

The implications of this shift are profound and perhaps insufficiently recognized. The shift of definition from a sole source to a competitive environment gives rise to a subtle form of technological transfusion. Since the two or three contractors are being "monitored' by a single government organization, there is a continual comparison being made of their work. The System Project Office (SPO) will poin out areas in which each contractor's work is deficient. A part of the source of the project office's insight is, no doubt, the work of the other competing contractors. The net result of this is that the government aids the contractor in allocating his engineering resource with what is almost certainly beneficial results. The technial quality of the proposals upon which the final source selection decision is made is almost certainly higher than would be the case in the absence of the competitive definition activities.

But there is another result that is quite important for the questions considered here. The technical proposals are likely to be more nearly equal in quality. Certainly they should all have a high probability of meeting the minimum requirement. Consequently, distinguishing among the proposals on the basis of technical quality alone will be more difficult than in the past, and the importance of quality differences for source selection will in all likelihood be smaller. As a result, price can become a more important source selection criterion, not because quality is less important, but because quality provides a less useful means of distinguishing among proposals than in the past. Even if quality is no less important, the image that observers can derive from source selection experiences emphasizes the importance of price.

Several real problems arise because of this image. In particular, it can give rise to "buying in" tactics where the price bid on the R&D contract is not related solely to an efficient cost but also to the contractor's expectations about future sales and about his

ability to negotiate favorable prices and/or changes on these future sales. The government is, of course, concerned not just with the price of the system R&D but with the price of the total program. Therefore, to make the source selection considerations of price more meaningful, the Air Force introduced the notion of contracting for development and a substantial proportion of the anticipated production run at the same time. The primary aim of this so-called "bundle bidding" concept is to associate a contractor's bid with both the development and a substantial part of the production of a system so that the contractor could not "buy into" a program and then "get well"* in subsequent negotiations in a sole source environment. A greater part of the total program is felt to be contracted for under meaningful competition.

The use of bundle bidding in the C-5A program raised several serious problems. In particular, because the contractor's commitment was for so much production, if he attempted to improve his profit situation beyond increasing his efficiency he had to seek contract changes or deliver deficient equipment. Consequently, the government produced a number of new contract provisions intended to protect its position. To inhibit the use of changes as a means of allowing the contractor to get well, a rather stringent change clause was introduced.** A correction of deficiencies clause was also added

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*"Get well" is a term frequently used in the defense industry to describe the situation where a contractor improves a bad financial position on an existing contract by negotiating a very favorable price on changes to the contract.

**For the airframe contractor in the C-5A program, changes other than value engineering changes, corrections of deficiencies, updating and modifications change kits, and some miscellaneous contractor services are to be priced as follows: (a) Changes with negotiated target costs of less than $100,000 (either up or down) are incorporated at no change in the target cost, target profit, or target ceiling; (b) Changes with a negotiated target cost in excess of $100,000 but less than 1 percent of the target cost of total contract can carry a target profit of up to 10 percent so long as the cumulative amount of such changes is less than 3 percent of the initial contract target cost. If the cumulative target cost of such changes exceeds 3 percent of the initial target contract cost, the negotiated target profit on

to force the contractor to correct deficiencies in his product if so directed by the Air Force. In addition, the contract work statement was written using performance specifications, so that changes could be justified only in terms of performance improvements or degradations associated with the change cost.

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the additional changes will not exceed 2 percent; (c) Changes with negotiated costs exceeding 1 percent of the initial contract target cost are treated as program redirections and can carry target profits as high as 10 percent of the negotiated change cost target.

III. CONTRACTOR MOTIVATIONS

As was noted initially, the Total Package Procurement Concept is actually the amalgamation of three concepts -- the Contract Definition Phase, bundle bidding, and a series of contractual terms and conditions designed to inhibit changes and make the contract binding. The discussion of the impact that TPPC may have on innovation or product quality can be conceptually broken down into a discussion of the impact that each of these three concepts has. But it is important to realize that they complement each other in important ways. For example, CDP was originally designed to lead to a fairly binding incentive contract for development. The added requirement of arriving at a contract that covers production activities is bound to change the quality of the definition process. In particular, it makes the performance promises and design concepts arrived at in this phase more binding than in the past. In turn, the clauses dealing with changes and correction of deficiencies make the results of the definition activity still more binding.

The impact that these procedures have will depend upon the motivations of the contractor. Given his perception of the nature of the CDP and the source selection criteria, what type of product will he be motivated to propose? Once a source has been selected and a contract has been signed, how will he be motivated to perform the design and production tasks, and, in particular, what will be the impact on product quality? These motivations are complex and sometimes conflicting; although it is impossible to treat them exhaustively, it is probably worthwhile to enumerate them.

The most frequently mentioned motivation of the contractor is his desire to maximize profits on each of his contracts. This would lead him to minimize his costs by improving the efficiency of his operations and by designing the product to be as cheap to produce as possible. To the extent that higher product quality is correlated with higher product cost, he will be motivated to reduce the quality to the lowest

level acceptable to the customer, which presumably is the level of the minimum specifications in the contract. Performance incentives may tend to counteract this effect.

If a contractor's future sales were independent of his performance on current contracts, the desire to maximize profits on current contracts would be a dominant one. This independence does not hold generally. The possibility of obtaining follow-on orders and the desire to build a reputation for producing good quality equipment lead a firm to consider the impact that actions on current contracts will have on future sales. If the contractor feels that future sales will depend upon the quality of the product he is developing and producing, he will be motivated to provide better quality than he would if future sales were really independent of current performance.

In addition to these profit-oriented motivations, the contractor has other motivations that may affect his performance. Corporate pride in the quality of a product and the contribution it makes to national security will affect product quality. The motivations of individual engineers are not totally related to the profits of the firm. Finally, some contractors may be willing to assume more of the risk associated with new technological approaches than others. These motivations vary from firm to firm and within a firm over time. Clearly the impact of TPPC will depend upon the relative importance of the various motivations.

It is sometimes argued that business firms have some "acceptable" level of return on their near-term activities. So long as the prospective profits on current activities exceed this level of return, they will place considerable emphasis on long-term effects in their management decisions. However, if the expected return falls below the acceptable level, there is likely to be strong action to remedy the short-term situation with relatively less concern for long-term effects. In other words, if the firm expected to make a return of 10 percent on a current contract, it might be willing to

drop its return to 9 percent in favor of increased quality. However, if the firm expected to make only 3 percent, it might be quite unwilling to lower its current return to 2 percent to achieve the same increase in quality.*

*This view of contractor behavior is closely related to a theory of business firm behavior proposed by W. J. Baumol in Business Behavior, Value and Growth, New York, The Macmillan Company, 1959.

IV. TPPC AND INNOVATION

In discussing the impact of the TPPC on innovation or quality, it is convenient to consider two phases in the development process: the activities prior to the award of the contract (including the conceptual, definition, and source selection activities) and the activities subsequent to contract award. In addition, it is important to consider the impact of these procedures on the vendors and subcontractors as well as the prime contractor. The task of examining the question is made more difficult by the lack of a really good definition of quality and innovation. For the purposes of this Memorandum, innovation will be taken to be the incorporation of improvements in a design made possible by experimentation or analysis. Quality is taken to be the absolute level of usefulness or capability in a design. The questions to be addressed then are, Does TPPC inhibit the incorporation of improvements in the design in either the precontract or contract time period relative to alternative methods of procurement? And, Is a program conducted under TPPC likely to lead to a product of lesser quality than one conducted under another procedure? These questions are very closely related.

THE PRIME CONTRACTOR

During the conceptual and definition phases, the prime contractor is in a competition. He is seeking every means possible to win that competition, and he is being aided to some degree by the Air Force SPO or SPO Cadre as noted earlier. His actions in this phase of development are very dependent upon his perception of the criteria for the source selection. As was noted above, there are strong reasons to expect that in comparison with past procurements the technical quality of the various proposals will be more nearly equal (or less easily differentiated) because of the nature of the definition process. The price proposed by the prime contractor is therefore a more important factor in source selection than in the

past and hence weighs more heavily in the contractor's design considerations.

As a result, the quality of the systems proposed by the contractors will depend critically on the nature of the specification to which it is bid. As a minimum, the contractor is required to meet this specification. The degree to which he exceeds this specification depends upon his perception of the value that the Department of Defense attaches to performance improvements together with his expectations of how such improvements will be considered in the source selection process. He is concerned basically with what measures of effectiveness will be considered by the source selection board and what value is attached to increments in effectiveness. If these can be completely specified in the Request for Proposal there is little reason to expect an undesirable degradation of the quality of the system proposed under TPPC compared with other procurement systems. Development and production prices can be compared with the value of the effectiveness and a choice of source can be made.

There are, however, substantial difficulties in specifying all of the relevant measures of effectiveness in many systems and with associating value with these measures. For example, in multipurpose aircraft such as an air superiority fighter with some ground support capability, what is the relative importance to be attached to each mission and how are the measures of effectiveness to be combined? How are qualities such as maneuverability, speed, and ceiling to be incorporated into the measures of effectiveness? What is the value of increased effectiveness? These are difficult questions and they have never been adequately handled by analytic methods.

They become even more difficult if the proposed new system differs substantially in performance or concept from existing systems. The lack of precise and reliable criteria is a problem central to all source selections. In the past, source decisions have been made by relying upon the judgment of military and civilian personnel. These individuals not only relied on intuitive judgment but they made their

decision with the knowledge and expectation that changes in the ultimate winner's design could and would be made as the requirement and the technological potential for meeting the requirement became clear. The addition of bundle bidding and the contract provisions that inhibit change have substantially modified the ability to exercise judgment after the contract award. This places a greater burden on the CDP activities because a definition of a "correct" configuration becomes of prime importance.

Judgment can of course continue to play an important role in source selections for programs using TPPC. The issue, then, is whether at least one of the alternative proposals will incorporate the desired degree of quality. This depends in part upon the bidders' perceptions of the importance of price. If price is viewed as very important and if no clear guidance can be given as to the value of increments of performance, it is quite possible that the level of quality inherent in the proposals will suffer. This tendency can be countered in two ways. If the minimum specifications are very good, the quality levels in the proposals should be good. Moreover, if the government is effective in giving guidance to the contractor's preliminary design efforts the quality levels are likely to be better than the minimum specification. Obviously this puts a premium on the performance of the government personnel and makes them relatively more important to the definition process than they have been heretofore

The potential importance of price in source selection activities together with inadequate measures of effectiveness raise another problem. Most successful military aircraft have been characterized by a quality called growth potential. Basically this has been reflected in a capability to perform missions and utilize equipment that were not anticipated at the start of the development. This quality is important because it is difficult to anticipate all the directions the threat may take or all of the capabilities technological advances may permit.

Aircraft or missiles with little growth potential have been produced under development processes that do not include CDP or TPPC. The highly optimized B-58 is an example of an aircraft that has little growth potential and would be considered among our less successful development efforts. The Minuteman system has been extremely expensive to modify because the initial concept, as embodied in the missile and silo sizing, forced significant technological advances to be made just to improve guidance flexibility and allow defensive countermeasures to be incorporated. Advances would have been needed in any case but they were made more difficult by the constraints imposed by the initial Minuteman concept.

TPPC does not prevent the "excess capacity" that provides growth potential from being incorporated in the system. But the incentives to propose a system of minimum cost consistent with the specifications may make it difficult to obtain such growth potential. This is accentuated in situations where fairly narrow measures of effectiveness are specified to the contractor for use in formulating his design. It is not unlikely that in such cases the designs will tend to be highly optimized relative to those measures of effectiveness and at the expense of obtaining useful capabilities in situations not foreseen in the initial requirement. It is possible again that an intelligent statement of specifications can counteract this tendency.

In the time period prior to the contract award, there is one final effect that should be considered. The Contract Definition Phase is not supposed to be initiated until "technology is in hand." Many have argued that this provision of CDP has an important inhibiting effect on technology. They cite as evidence the belief that many of the most significant development programs of the 1950s would not have been started had this provision been imposed at the time, and that important innovations would not have occurred without these programs. The validity of this position depends upon the degree to which innovative activities formerly conducted as a part of systems developments are conducted with other sources of funding. This is

a subject beyond the scope of this Memorandum. It is important to note, however, that the addition of the concept of bundle bidding and change-inhibiting contract clauses to CDP reinforces the effect of the requirement to use proved technology. Contractors, facing long-term contractual commitments, will certainly attempt to reduce the risk of design and production problems by trying to use proved technical concepts.

After the contract has been signed, there seem to be two major possibilities for quality erosion or inhibition of innovation. First, the tightness of the price may lead the contractor to cut corners in his design and to produce a deficient product. Second, the strong clauses inhibiting changes, if accompanied by a reluctance of the government to permit changes, may prevent a desirable adaptation of the program to new threats or technological possibilities. In both cases, the effects will depend heavily on the activities and decisions of the government as well as the contractor.

The first effect is related to the point made earlier about the shift in the relative importance of contractor motivations as expected profit levels decrease. In this situation, and in the absence of strong performance incentives, the contractor will have a short-term incentive to deliver a product that just meets minimum specifications. The quality of the product depends upon a myriad of design decisions on individual components. It seems quite possible that in pursuing the minimum quality specifications the contractor could end up delivering a system that was deficient because of an unanticipated interaction of some of these components. This possibility would be heightened if the system needed to use new and relatively untried components. The deficiencies could turn out to be ones that the government could not or would not choose to force the contractor to correct because of the expense and time delays involved.

The government is supposed to maintain visibility and be able to move in quickly to forestall such an occurrence. However, to make the contract truly effective, the government also wishes to

stay out of the design process as much as possible. Not only is this consistent with the intent of fixed price incentive contracts, but it also prevents the government from becoming a party to design decisions and hence liable for their consequences along with the contractor. The desire to "disengage" from contractor design activities makes it extremely difficult to maintain a high quality cadre of government technical talent in a purely monitoring role. The job simply does not have the technical challenge and the feeling of participation necessary to attract quality personnel. Also, in the design decision this desire to disengage may prevent timely action even if the technical team begins to recognize that a problem exists.

The second problem -- a failure to adapt the program to new threats or technological possibilities -- can arise in the contract period and is directly related to the desire of the government to inhibit changes. This desire is based upon a fear that the incorporation of contract changes will tend to make the contract less binding and hence invalidate the intent of TPPC. This fear is well expressed in a quote from Total Package Procurement Concept:*

> The weakest points in the chain leading from competitively established initial contract commitments to final contract realizations are those situations in which the contract is reopened for negotiation during the course of the program and therefore on a sole source basis.

New technology can make the system substantially more effective. Program adjustments may make the system more effective in the face of important changes in the threat. If this desire to inhibit changes prevents such technological or program adjustments, a serious erosion in quality could occur. In principle, a change should be made in the system if the improved system effectiveness is great to justify the expenditure on that change. This decision should be independent of the total cost of previous changes or the absolute cost of the change itself. The change-inhibiting clauses in the C-5A

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*Total Package Procurement Concept, op. cit., p. 11.

contract were apparently included because it was felt that decisions on changes were not being properly made under established procedures. There is no reason to expect that "small" changes totaling 3 percent or less of the contract value will be appropriated in the case of the C-5A, for example.

It is certainly true that if a contractor expects a substantial number of changes to be made, he may price his proposal with some anticipation of "getting well" on the changes. This possibility should not be allowed to interfere with desirable changes and indeed, if there is a reasonable expectation that a large number of changes will be desirable, the program should not be a candidate for TPPC.

There is one important manner in which TPPC may promote innovation; this is related to the government's desire to disengage from contractor design activities and to use performance oriented specifications. The reduced requirements for obtaining government approval of design decisions, coupled with the lack of specified design solutions in the contract work statement, should allow the contractor greater freedom to innovate. These innovations, however, would tend to emphasize cost savings rather than performance improvements unless there are appropriate performance incentives in the contract.

AIRFRAME SUBCONTRACTOR

The impact of TPPC upon the airframe subcontractor seems likely to have minimal effects upon the innovation involved in the design. Subcontracts will probably be for manufacturing to specifications provided by the prime contractor. In cases where relatively standard airframe construction is involved, the long-term commitments and change inhibitions imposed by TPPC should not pose a significant difficulty. Because of the emphasis on cost, innovations in manufacturing processes should be encouraged.*

*It is possible that in the C-5A program certain terms and conditions associated with changes and corrections of deficiencies were injudiciously applied in subcontracts. There seems to have been

With respect to subcontracting, some evidence is available on the correlation of technical quality with the price quoted. In a study of the C-141 subcontracting experience, Johnson and Hall found little evidence of a significant relationship between the technical quality of a proposal and the price associated with that proposal.* Moreover, in the C-141 program the subcontracting procedures had much in common with the C-5A program. The bids obtained covered development plus an option for a substantial production program. Thus, in a program of the complexity of the C-141 at least, stringent price competition did not seem to affect the quality of the subcontracting.

EQUIPMENT SUBCONTRACTORS AND SUPPLIERS

In discussing the effects of TPPC on equipment suppliers, it is important to distinguish their operations from those of airframe manufacturers. Data on sources of funding for development activities carried on by equipment subcontractors and suppliers are virtually nonexistent. It appears, however, that substantial proportions of the initial development of new equipment are financed by the firms themselves. This development is generally carried on in anticipation of sales for a number of different weapons systems. In large subsystems, critical components and techniques are frequently developed prior to competitions as a means for raising technical confidence in the proposal while the detailed subsystem design and refinement is expected to be accomplished subsequent to the award of a contract to one of the bidders.

In the short run, and specifically on the C-5A program, TPPC would have little effect on the quality of the proposals submitted by these subcontractors and suppliers. It is possible that some of

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considerable confusion during the subcontract awards. This seems not to reflect any inherent weakness in the concept however; it is simply another example of difficulties associated with new concepts and procedures.

*R. E. Johnson and G. R. Hall, Public Policy Toward Sub-Contracting, The RAND Corporation, RM-4570-PR, May 1965, pp. 27-28.

the contractors selected less adventuresome methods of achieving a given performance in order to reduce the risks associated with the long-term commitment, but generally the companies were dealing with hardware and techniques developed prior to the introduction of TPPC. In the longer run, however, it is quite possible that TPPC, together with the CDP, may have a more significant effect. The major factor that could motivate equipment suppliers to modify their behavior is the apparent importance of price, already noted above. The anticipation that price will be the determining factor in the award may lead to a redistribution of company sponsored efforts towards cost-saving innovations rather than performance improving innovations. The important unanswered question here is how much of the significant performance improving innovation truly flows from company sponsored activities. Aside from this point, major equipment suppliers are likely to be affected in much the same way as the prime contractor.

V. AVAILABLE ALTERNATIVES

From the previous discussion it is clear that TPPC is more likely to have adverse effects on innovation and technical quality in some types of development programs than others. While precise criteria seem impossible to specify, TPPC seems more likely to inhibit innovation or erode quality in:

1) programs where uncertainties concerning the requirements for the use of the system are great;

2) programs where there is an extreme time urgency that precludes adequate definition for the purposes of writing a contract incorporating TPPC;

3) programs where the needs to be met by the system require the use of relatively new and untried technology;

4) programs where the criteria for measuring improvements in systems effectiveness are diffuse and qualitative.

A program such as the C-5A has none of these characteristics whereas programs such as Atlas, Titan, and BMEWS shared many of them. In most programs it will not be so clear that TPPC is applicable and difficult judgments will have to be made as to what development and procurement procedures should be used.

There are many ways to conduct development projects. They can be initiated with varying degrees of definition and varying degrees of participation by the government. Projects can be initiated after extensive exploratory work has been accomplished in components or this exploratory work can be included as a part of the development task. One of the faults of large organizations which are responsible for development activities is that they tend to seek a single development policy that is appropriate to all development, at all times, and with all contractors. Moreover, these procedures frequently are more nearly oriented to meeting the needs of the bureaucratic organization responsible for the development than to meeting the needs of the development project at hand. Because of the variety of conditions

under which developments are initiated, it is desirable to have a number of different means of conducting and contracting for development. With this in mind, a number of alternatives can be suggested.

TPPC with Modification

As one alternative means for contracting and carrying on a development, relatively minor modifications of the current TPPC procedures could be introduced. For example, a modified and less stringent change clause could be introduced and a different correction-of-deficiencies clause could be used. In this instance, improved decisionmaking procedures on changes should be provided because the introduction of unnecessary changes will tend to eliminate many of the benefits of the concept.

TPPC with a More Effective Incentive Arrangement

It can be argued that one way to obtain more than a minimal system is to provide guidance and rewards to the contractor in the form of incentive payments for useful increments in system performance above the minimums specified in the contract. In this way a contractor is motivated to provide more system performance whenever the cost of doing so is expected to be less than the additional value to the government of that performance. In principle this is a good idea. In practice it has been difficult to implement. What is the value of an additional 10 percent range in a transport or of an additional quarter hour of loiter time in a fighter for example? In highly structured situations, it may be possible to place a dollar value on increments in performance. Such value will depend upon the particular scenario used in the evaluation. Instead of specifying all combinations of valuable performance improvements (the net effect of establishing an incentive schedule) it may be simpler and just as effective to evaluate possible improvements as they become available, which is the more traditional way of accomplishing the task. In this case, one runs the risk of compromising the aims of TPPC as has been noted.

It is important to note that the ability to specify the value of additional increments in performance varies greatly. In satellite systems for example, quite explicit value can be given to increments in reliability. In most systems, improvements in the maintainability can be measured. This would seem to be a good area for incentives.

Contract Definition Only

This means of development has been used extensively over the past few years. While it is true that one cannot obtain commitments on much of the program cost, there seems to be substantial reductions in the error of cost and schedule estimates due to improved initial planning. In such a development program, changes are more easily incorporated and contractors will be willing to take greater technical risks since they are not tied to a fixed production price.

"Special Projects"

A number of projects leading to improved intelligence capabilities are now conducted in a manner quite different from ordinary military systems. It is claimed these projects are characterized by technical inventiveness, low production levels, low development costs, and generally small project organizations. It seems quite possible in situations where requirements are urgent, where inventiveness is needed, and where the financial scale of the project is not too large that there is much to be gained by the methods used in special projects. Candidates for this treatment would include air-to-air and air-to-surface weapons, avionics subsystems, sensors, and possibly small aircraft. One would expect the special projects activities to take the place of much of the CDP.

Richer Advanced and Exploratory Development Efforts

The TPPC, together with CDP, requires that technology be well in hand. It is bound to lead to conservative weapon systems developments which in turn will lead to obsolescent weapons unless a

technological base is provided outside the systems development process. The Exploratory Development and Advanced Development programs are intended to do this and have succeeded in many instances. For example, the engines in the C-5A were initiated under Advanced Development funding. A very alert technical organization is required to foresee the critical technological needs and force development efforts through. If an advanced development effort is needed, it nominally requires 18 months to go from planning initiation to funds availability, a length of time that can be shortened in exceptional instances when there is general agreement on the need. Since the innovation associated with a new system proceeding through CDP (and using TPPC) is so dependent on the technology available at the initiation of the program, a careful examination of the planning, funding, and conduct of these programs seems merited.

VI. CONCLUSIONS

The Total Package Procurement Concept represents the addition of bundle bidding and a group of contractual terms and conditions inhibiting changes to the Contract Definition Phase. As a result, most of the discussion has centered on the effects the CDP may have on innovation. As has been noted, generalizations upon the effects of TPPC on innovation or product quality are difficult to make. Nonetheless, several points can be made on the basis of the earlier discussion.

o TPPC has the effect of making the results of the CDP far more binding, and of reducing the potential for program improvements subsequent to contract award. This implies that in programs using TPPC most innovation must take place either during the CDP or in programs conducted outside the systems development program altogether. The question of whether the TPPC inhibits innovation is thus quite dependent on both the quality of the Defense Department's Exploratory and Advanced Development programs and the independent research and development activities of the defense industries. The usefulness of these research and development activities to any systems development program will vary and will depend upon the quality of the planning of the Exploratory and Advanced Development programs.

o The introduction of the TPPC should result in a shift of the creative activities of government personnel from the acquisition phase to the definition phase. If their participation in the acquisition phase has been responsible for maintaining quality or promoting innovation, this shift may have an adverse affect. On the other hand, more effective participation on their part in the definition phase may improve the quality of the program.

o Whether or not TPPC inhibits innovation is dependent upon the quality of the contract definition and source selection activities. There is an important conflict here. The CDP is an attempt to formalize an important phase of development and to make it more objective.

But the source selection must be based upon many subjective judgments because the quality of the available analytical techniques is not very good. If the desire for objectivity results in slighting subjective judgments, inhibition of technology or erosion of quality may occur.

o Once a contract has been signed, decisions on changes should be made without regard to artificial contractual constraints. If changes in the threat or improvements in technology make program changes desirable they should be made even at the expense of allowing the contractor to improve his cost position. Unnecessary changes should be inhibited by effective management. If, at the outset of the program, it is expected that substantial changes will have to be made, the TPPC should probably not be applied.

o TPPC is most likely to have serious adverse effects on innovation and quality in systems developments where the requirement is uncertain, the need is extremely urgent, the technology that must be used is unproven, or where the measures of systems effectiveness are diffuse and qualitative.

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10. ABSTRACT

An assessment of the potential impacts of the Total Package Procurement Concept (TPPC), introduced in the C-5A program, on innovation in new developments and on the quality of the resulting systems. One of the tentative conclusions is that TPPC seems most likely to have adverse effects in situations where the requirement is uncertain, the need is extremely urgent, the technology is unproved, or the measures of system effectiveness are diffuse and qualitative.

11. KEY WORDS

Procurement
Product improvement
Research and development
Military contracts
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